PATENT SPECIFICATION

NO DRAWINGS

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1,176,955

Date of filing Complete Specification: 17 July, 1968.

Application Date: 17 July, 1967. *No. 32690/67.*

Complete Specification Published: 7 Jan., 1970.

Index at acceptance: —H1 D(5G, 9Y, 9A, 9D, 11Y, 11X, 12B47Y, 12B13Y, 12B1, 12B4, 12A, 12C, 35); C4 S(33Y, 71Y, 713, 72Y, 726, 727, 728, 729, 730, 747, 750, 76Y, 779, 781, 782, 783)

International Classification: —H 01 j 61/28

COMPLETE SPECIFICATION

Improvements in or relating to Low Pressure Mercury Vapour Fluorescent Electric Discharge Lamps and their Manufacture

We, THE GENERAL ELECTRIC AND ENGLISH ELECTRIC COMPANIES LIMITED formerly The General Electric Company Limited, of 1 Stanhope Gate, London, W.1., a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to low pressure mercury vapour fluorescent electric discharge lamps of the type (hereinafter referred to as the type specified) comprising a tubular glass discharge envelope which contains mercury for providing a mercury vapour filling in operation of the lamp, and an electrode at each end of the said envelope, between which electrodes an electric discharge is arranged to pass through the mercury vapour in operation, the said envelope also containing a quantity of rare gas at a few millimetres pressure for facilitating starting of the discharge, and having on its internal surface a coating of fluorescent material which is excitable to fluorescence by the passage of the electric discharge through the mercury vapour filling when the lamp is in use. The invention also relates to methods of manufacturing lamps of the type specified.

It is known that lamps of this type operate at maximum efficiency with a particular vapour pressure of the mercury filling, the efficiency of the lamp being reduced if the mercury vapour pressure is either less than, or in excess of, the optimum value. The actual mercury vapour pressure attained in operation of the lamp under any given conditions of ambient temperature depends upon the temperature of the envelope wall, which is itself dependent upon both the ambient temperature and the power loading per unit area of the wall: the optimum mercury vapour pressure is known to be obtained with a wall temperature at the coolest part of the envelope (hereinafter referred to as the "minimum wall temperature") of approximately 40°C. However, many fluorescent lamps of ratings commonly used usually attain minimum wall temperatures above 40°C. under normal conditions of use, and therefore operate with mercury vapour pressure in excess of the optimum and hence with less than the maximum possible efficiency. It has accordingly been appreciated that it is desirable to employ some means for reducing the mercury vapour pressure produced during the operation of lamps of the type specified, especially in the cases of lamps of relatively high loadings (that is to say loadings exceeding 0.4 watt per square inch of envelope surface) and/or designed for operation in conditions of high ambient temperature, and it has been proposed to design such lamps so that at least a part of the envelope is maintained at a lower temperature than that normally attained in operation.

Another method of reducing the mercury vapour pressure in lamps of the type specified, which has been proposed, consists in introducing the mercury into the envelope in the form of an amalgam with one or more metals, for example cadmium, silver, copper, gold, aluminium, lead or zinc, the presence of free liquid mercury within the envelope being eliminated: this proposal is based on the realisation that the pressure of mercury

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vapour in the presence of an amalgam is lower, at any given temperature, than that in the presence of free mercury. It has further been proposed to employ mercury-indium amalgams containing at least 50% by weight of indium, in lamps designed for operation at high loadings and high wall temperatures.

It is an object of the present invention to provide an improved form of lamp of the type specified which is designed to operate with a high wall temperature, resulting either from a high loading or from operation in conditions of high ambient temperature, for example in an enclosed fitting, which lamp incorporates means for reducing the mercury vapour pressure produced in operation.

According to the invention, in a low pressure mercury vapour fluorescent electric discharge lamp of the type specified and designed in normal operation to develop a minimum wall temperature, as hereinbefore defined, exceeding 55°C, the coating on the internal surface of the envelope includes one or more of the metals copper, silver, gold zinc, aluminium, thallium, tin, lead, bismuth, iron, cobalt, nickel, dispersed in the form of the finely divided powder in association with the fluorescent material, the said metal or metals being so dispersed for promoting rapid formation of an amalgam thereof with the mercury filling during processing or initial operation of the lamp, with consequent reduction of the mercury vapour pressure produced in operation, and the total amount of said metal or metals present exceeding 0.3 gram atom per gram atom of the total mercury present within the envelope. Preferably the said metal or metals is or are substantially uniformly dispersed in association with the fluorescent material.

All of the metals specified in the foregoing paragraph as suitable for inclusion in the envelope coating of a lamp in accordance with the invention are capable of forming an amalgam with the mercury present in the envelope, under the conditions of processing and/or initial operation of the lamp. Amounts of the amalgamating metal corresponding to and higher than the minimum specified are sufficient to amalgamate with all the mercury normally present in these lamps, so that there is no residual free liquid mercury. In addition, the metals referred to are suitable for incorporation in such lamps in the manner specified, since they do not evaporate to a significant extent during the processing of the lamp subsequent to the formation of the coating, which includes the step of baking the coated envelope at 500°C to 550°C, and since they do not undergo any undesirable reactions with other materials present, in particular with the fluorescent material or with the glass of the envelope. Some of the metals, however, especially copper, aluminium, lead and iron, are liable to oxidise on heating in air, so that it might be necessary to take precautions to prevent oxidation of these metals during the baking step in manufacture of the lamp. The preferred metals for use in a lamp in accordance with the invention are tin and lead.

The metal powder should not be present in so large an amount, nor consist of very small particles such that the amount of metal used is so widely dispersed in the envelope coating, as to result in the absorption of an appreciable amount of the light output of the lamp in operation. On the other hand, particles of too large a size might give rise to difficulties in the formation of the envelope coating in manufacture of the lamp, as will be explained below. Preferably the metal powder consists substantially of particles of sizes in the range of 10 to 50 microns.

By forming an amalgam with the mercury filling of the lamp, the metal included in the envelope coating causes a reduction of the mercury vapour pressure produced in operation of a lamp of the type specified. The reduction in mercury vapour pressure obtained with the amount of such metal employed in accordance with the present invention, as specified above, results in an increase in the efficiency of a lamp of this type which develops, in normal operation, a minimum wall temperature exceeding 55°C., due to a high power loading and/or to the conditions under which the lamp is operated. Thus the use of the amount of amalgamating metal specified herein is advantageous in lamps which are designed to operate with a power loading exceeding 0.4 watt per square inch of the internal surface of the envelope, or in lamps designed to have a lower wall loading but intended to be operated at a high ambient temperature which will give a minimum wall temperature above 55°C, such as may be attained, for example, in a closed fitting, or in lamps which both have a high loading and are operated under conditions of high ambient temperature. The amount of amalgamating metal incorporated in a lamp will depend upon the wall temperature which the lamp is expected to attain in operation, the amount of metal required to give the optimum increase in efficiency increasing with increasing wall temperature. For lamps designed to operate at very high minimum wall temperatures, for example 70°C or higher, the gram atom quantity of amalgamating metal required to give the optimum increase in light output will be nearly equal to twice the gram atom quantity of mercury constituting the lamp filling.

Thus in one example of a lamp in accordance with the invention, which lamp has a straight tubular glass envelope 5 feet long

and 1½ inches in diameter, containing an initial filling of 60 mg of mercury and argon at a pressure of 2.5 mm of mercury, and which is designed to dissipate 80 watts and is operated while enclosed in a fitting in which the ambient temperature developed is 42°C, whereby the lamp envelope attains a minimum wall temperature of 70°C. in operation, the envelope coating consists of approximately 8 grams of a halophosphate fluorescent material and 60 mg of powdered tin. This corresponds to 1.69 gram atom of tin per gram atom of mercury initially provided.

A second example, of a lamp in accordance with the invention which is designed to operate at a high power loading, is a lamp having a tubular envelope 4 feet long and 1½ inches in diameter, and designed to dissipate 100 watts in normal operation, giving a wall loading of 0.442 watt per square inch; this loading gives a minimum wall temperature of 64°C at an ambient temperature of 25°C. The initial filling of the envelope consists of 50 mg of mercury and a mixture of 80% neon and 20% argon, by volume, at a pressure of 2 mm of mercury, and the envelope coating consists of approximately 6.5 grams of a halophosphate fluorescent material and 16 mg of powdered tin. This corresponds to 0.54 gram atoms of tin per gram atom of mercury initially provided.

The amounts of tin included in the envelope coatings of the lamps of the examples in both cases result in a reduction in the mercury vapour pressure produced in operation of the lamps to a value corresponding to that obtained with a minimum wall temperature of approximately 40°C. in a lamp containing free mercury and no amalgamating metal.

The manner of incorporating an amalgamating metal or metals in a lamp in accordance with the invention, namely in a finely dispersed state in association with the fluorescent coating on the lamp envelope, is advantageous in promoting rapid formation of the amalgam initially, and rapid reabsorption of the mercury vapour by the metal and/or amalgam particles after a period of operation of the lamp. Since the amalgamating metal does not appreciably evaporate during processing or operation of the lamp, the metal particles, and hence the amalgam particles into which they are converted, remain dispersed in the envelope coating throughout the life of the lamp.

A further advantage of including the amalgamating metal in the envelope coating is convenience in manufacture of the lamp, since the metal can be introduced into the envelope simultaneously with, or prior to, the fluorescent material, and no introduction of metal or amalgam after processing of the lamp is necessary. It is to be understood that the phrase "dispersed in association with the fluorescent material", as used herein, means that the metal powder may be dispersed in the layer of fluorescent material, or may be deposited at a separate non-continuous layer on the envelope wall between the glass and the fluorescent material.

Thus in one method of manufacturing a lamp in accordance with the invention, the required metal powder is dispersed in the suspension of fluorescent material employed for forming the coating of the said material on the internal surface of the envelope, the combined suspension being applied to the envelope surface in known manner, for example by pouring the suspension through the tubular envelope in such a way that the whole of the internal surface is covered with the suspension or, preferably, by drawing the suspension up into the vertically supported tube under vacuum and then allowing the excess suspension to run out of the tube. Any liquid medium usually employed for the fluorescent material suspension may suitably be used: a preferred liquid medium is a solution of an organic binder in an organic solvent, for example nitrocellulose in butyl acetate; alternatively an aqueous solution of a water-soluble binder, such as poly-ammonium methacrylate, can be used. Preferably separate suspensions of the fluorescent material and the metal powder are initially made up and are then mixed, the mixed suspension being stirred continuously during application to the tube, to prevent the metal particles from settling out: it is preferred to use a metal powder consisting of particles in the size range of 10 to 50 microns, as indicated above, in order to reduce the tendency of the metal to settle out and to make it possible to obtain a substantially uniform dispersion of the metal powder in the suspension. The depositing of the coating of the suspension on the envelope is followed by drying and baking to remove the binder, in the usual manner to leave a layer of the fluorescent material with the metal powder dispersed therein.

In another method of manufacturing a lamp in accordance with the invention, the internal surface of the envelope is first coated with a suspension of the metal powder, this coating is dried, and a second coating of a fluorescent material suspension then applied in the usual manner, and dried, the binders finally being removed simultaneously from both coatings in a single baking step. If desired, different liquid media may be employed for the two suspensions. This method is advantageous in some cases, especially where the metal powder particles are of somewhat larger sizes than those referred to above, since it is possible to use a more viscous liquid medium for the metal powder suspen-

sion than would be suitable for the fluorescent material suspension, thus enabling the larger metal particles to be retained in suspension and hence avoiding the necessity of a preliminary milling of the metal powder to a very fine particle size.

Whichever of the above methods is employed for forming the envelope coating, the remaining steps in the manufacture of the lamp are carried out in the conventional manner.

WHAT WE CLAIM IS:—

1. A low pressure mercury vapour fluorescent electric discharge lamp of the type specified and designed in normal operation to develop a minimum wall temperature, as hereinbefore defined, exceeding 55°C, wherein the coating on the internal surface of the envelope includes one or more of the metals copper, silver, gold, zinc, aluminium, thallium, tin, lead, bismuth, iron, cobalt, nickel, dispersed in the form of a finely divided powder in association with the fluorescent material, the said metal or metals being so dispersed for promoting rapid formation of an amalgam thereof with the mercury filling during processing or initial operation of the lamp, with consequent reduction of the mercury vapour pressure produced in operation, and the total amount of said metal or metals present exceeding 0.3 gram atom per gram atom of the total mercury present within the envelope.

2. A lamp according to Claim 1, wherein the said metal or metals is or are substantially uniformly dispersed in association with the fluorescent material.

3. A lamp according to Claim 1 or 2, wherein the said metal powder consists substantially of particles in the range of 10 to 50 microns in size.

4. A lamp according to any preceding Claim, which is designed to operate with a power loading exceeding 0.4 watt per square inch of the internal surface of the envelope, and/or which is designed to be operated at an ambient temperature such that, in normal operation, the lamp will develop a minimum wall temperature exceeding 55°C.

5. A lamp according to Claim 4, which is designed to operate at a minimum wall temperature of at least 70°C., and wherein the total gram atom quantity of the said metal or metals included in the envelope coating is nearly double the gram atom quantity of mercury within the envelope.

6. A low pressure mercury vapour fluorescent electric discharge lamp having on the internal surface of the envelope a coating consisting of halophosphate fluorescent material and tin powder, substantially as described in either one of the foregoing specific examples.

7. A lamp according to any preceding Claim, wherein the metal powder is disposed in the layer of fluorescent material on the internal surface of the envelope.

8. A lamp according to any one of the preceding Claims 1 to 6, wherein the metal powder is deposited as a separate layer on the envelope wall between the glass and the fluorescent material.

9. A method of manufacturing a lamp according to Claim 7, which includes the steps of dispersing the required metal powder in a suspension of fluorescent material, in a liquid medium containing a binder, to be employed for forming the coating of the said material on the internal surface of the envelope, applying the combined suspension of fluorescent material and metal powder to the envelope surface in known manner, drying the coating of the suspension so formed, and baking the envelope to remove the binder from the coating.

10. A method according to Claim 9, wherein separate suspensions of the fluorescent material and the metal powder are initially made up and then mixed.

11. A method of manufacturing a lamp according to Claim 8, which includes the steps of first coating the internal surface of the envelope with a suspension of the required metal powder in a liquid medium containing a binder, drying the metal powder coating, applying a second coating of a fluorescent material suspension in a liquid medium containing a binder, drying the second coating, and baking the envelope to remove the binders from both coating simultaneously.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1970.
Published by the Patent Office, 25, Southampton Buildings, London W.C.2, from which copies may be obtained.